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MICRODENTICLES: AQUEOUS CORROSION TEXTURES ON WEATHERED CHAIN SILICATES AS TERRESTRIAL ANALOGS OF PYROXENE ALTERATION IN MARS METEORITES

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Denticulated margins (also known in older literature as "sawtooth," "cockscomb," or "hacksaw" terminations) are a common feature of pyroxenes and amphiboles, visible in transmitted-light microscopy of grain mounts and thin sections, and by electron microscopy. Denticles are remnants of undissolved material that formerly constituted the walls between elongate etch pits (the characteristic aqueous-dissolution form of chain-silicate minerals) [1], and occur where a grain boundary, transmineral fracture, or dislocation array transects the crystal at a high angle to the z-axis [1]. Denticles occur widely in terrestrial near-surface materials that have experienced low-temperature aqueous alteration, including chemically weathered regoliths, soils in a variety of climatic and geomorphic settings, sediments, and sedimentary rocks [1–5]. Ranges of dissolution forms and dimensions (commonly tens of microns in length) are identical on both pyroxenes and amphiboles in these materials [1–4]. Denticles are much less common on surfaces of chain-silicates altered by aqueous solutions at higher temperatures.

Microdenticles (with lengths in the micron-submicron range rather than tens of microns) are developed on the lateral surfaces of larger "classic" denticles on various naturally weathered amphiboles and pyroxenes from weathered regoliths at several terrestrial localities. Microdenticles share the shape and orientation of the larger, more typical denticles, suggesting similar crystallographic controls on the corrosion process. However, because the elongate pointed forms are on surfaces closer in orientation to prism faces than to (001) termini of the chain silicate crystals, these arrays of microdenticles more closely resemble a surface covered with imbricate pointed scales than a sawtooth margin. The arrays of imbricate microdenticles are formed by aqueous alteration during weathering of chain-silicates; they are later-stage corrosion forms on already corroded surfaces of chain-silicate minerals that show larger-scale evidence of typical weathering [1, 4].

The scaly, imbricate microdenticles on terrestrial chain-silicates are demonstrably formed by low-temperature aqueous alteration (weathering). Furthermore, they are similar in size, shape, and distribution to microdenticles on pyroxenes in several Mars meteorites [5, 6]. These similarities support previous proposals of a low-temperature aqueous origin of microdenticles and related corrosion textures in Mars meteorites [5, 6].

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DEPTH PROFILING OF GENESIS SOLAR WIND COLLECTORS WITH LASER POST-IONIZATION SNMS

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The samples returned to Earth by the Genesis mission of NASA's Discovery Program contain a record of the elemental and isotopic abundances of the solar wind. This record is implanted in the near-surface region of the sample collectors allowing the solar wind material to be distinguished from terrestrial contamination, which occurred due to the abrupt landing of the Genesis spacecraft. At Argonne National Laboratory, we have recently developed a new laser post-ionization secondary neutral mass spectrometer (LPI–SNMS) called SARISA, which is capable of accurate measurements of ultra-trace concentrations of many metallic elements implanted in Genesis solar wind collectors. In this work, we will report results of our measurements of abundances of Mg in two types of such collectors, silicon and diamond-like carbon (film on silicon). These depth profiling measurements were conducted in resonance-enhanced multi-photon ionization (REMPI) regime, in two-color scheme with two Ti-sapphire post-ionization lasers tuned to 285.30 nm and 375.66 nm wavelengths, with the repetition rate of 1 kHz.

To make our analyses quantitative, we used two specially prepared standard reference samples, made from exactly the same materials as the flown Genesis collectors and implanted with a known fluence of 43 keV Mg ions: 2×10^{13} at/cm^2 in diamond-like carbon and 1.1×10^{13} at/cm^2 in silicon. The ^{25}Mg isotope was significantly enhanced in these reference samples in order to help distinguish the implant from any terrestrial surface contamination (where ^{24}Mg has the highest abundance). The measurements of these standards allowed us to characterize the actual efficiency and detection limits of the new SARISA instrument: the useful yield of the instrument peaked at about 20% with a mass resolution of ~2000 and detection limits corresponded to <50 parts per trillion.

We measured concentration versus depth profiles for Mg in solar wind collectors (Si and diamond-like carbon, respectively) and compared them to Mg implant standards. One apparent feature of the solar wind implants was that maximums of their profiles were broad, with apparent diffusion of the implanted atoms towards the surface. Since the Genesis solar wind collectors were subjected in space to intense bombardment by protons and alpha-particles, and solar light heated them to the temperature of ~200 °C for nearly 2 years, this feature can be explained by radiation-enhanced thermal diffusion processes. The total fluences of Mg in solar wind determined from our measurements were: $(2.74 \pm 0.20) \times 10^{12}$ and $(2.46 \pm 0.20) \times 10^{12}$ at/cm^2 for Si and diamond-like carbon collectors, respectively (at 2σ error level). More detailed studies of diffusion processes in these collectors are needed to determine in what extent this minor discrepancy in fluences is caused by losses of the collected material due to processes of diffusion and surface sputtering by solar wind.

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